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ABSTRACT

A prospective longitudinal investigation related 76 maternal and infant variables to performance on the Metropolitan Readiness Tests (MRT) at age six. The 1,245 study subjects have been followed since birth. Their distribution on measures of intelligence and socioeconomic status is essentially normal. Subjects with high MRT scores were found to differ significantly from subjects with low MRT scores on 20 maternal and infant characteristics. Low readiness scores were found associated with higher total number of abnormalities at birth, more manifest abnormal skin conditions at birth, lower scores on measures of mental and motor development at 8 months and more neurological abnormalities at 1 year of age. Mothers of low readiness subjects were in general older, of lower socioeconomic status, and had had more pregnancies than mothers of high readiness subjects. When all 76 variables were used to predict readiness scores for the total sample, the resulting multiple correlation coefficient of .57 accounted for 33 percent of the variance in MRT scores. (Author/GO)

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THE RELATIONSHIP OF MATERNAL AND INFANT VARIABLES TO SCHOOL READINESS

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Abstract

A prospective longitudinal investigation related 76 maternal and infant variables to performance on the Metropolitan Readiness Tests (MRT) at age six. The 1,245 study subjects have been followed since birth. Their distribution on measures of intelligence and socioeconomic status is essentially normal. Subjects with high MRT scores were found to differ significantly from subjects with low MRT scores on 20 maternal and infant characteristics. When all 76 variables were used to predict readiness scores for the total sample the resulting multiple correlation coefficient of .57 accounted for 33 percent of the variance in MRT scores.

*The research reported herein was performed pursuant to a grant (OEG-32-33-0402-620) from the National Institute of Education, U.S. Department of Health, Education and Welfare. Data were also made available through the cooperation of the Minnesota section of the Collaborative Project supported by the National Institute of Neurological Diseases and Stroke (Public Health Service grant Ph-43-68-9).

The Relationship of Maternal and Infant Variables to School Readiness[1]

Rosalyn A. Rubin, Bruce Balow, Jeanne Dorle

University of Minnesota

Statement of the problem

During the past few decades a number of research investigations have reported evidence which tentatively supports the hypothesis that a variety of maternal and perinatal abnormalities may be associated with later impairment of school functioning. Kawi and Pasamanick (1959) reported a significantly higher incidence of pregnancy and birth complications among a group of 205 poor readers who were compared with a control group matched for sex, race and maternal age. Corah and his associates (1965) found that children who had suffered postnatal anoxia performed less well on measures of reading at age seven than did nonanoxic children born during the same period. Wiener (1968) in his longitudinal study of prematurely born children concluded that low birth weight children were impaired on measures of reading and arithmetic obtained at 12-13 years of age.

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[1]The research reported herein was performed pursuant to a grant (OEG-32-33-0402-620) from the National Institute of Education, U.S. Department of Health, Education and Welfare. Data were also made available through the cooperation of the Minnesota section of the Collaborative Project supported by the National Institute of Neurological Diseases and Stroke (Public Health Service grant Ph-43-68-9).

The majority of research on this topic has been retrospective in nature thus suffering from the errors of recall, lack of comparability of data among subjects and the distorting effects of current status upon memories of past behaviors and events which have been associated with this particular methodology in the past. Those prospective studies which have been reported have typically dealt with populations weighted toward the lower end of the socio-economic scale (Luong, 1970; Wiener, 1968; Kawi & Pasamanick, 1959) or focused upon outcomes associated with a single birth abnormality such as prematurity (DeHirsch, Jansky & Langford, 1966; Wiener, Rider, Oppel & Harper, 1968; Robinson & Robinson, 1965).

The purpose of the present investigation is to determine the extent to which an extensive set of maternal and perinatal variables gathered on a population which is normally distributed on measures of IQ and SES may be related to performance on a measure of school readiness prior to first grade entrance. The present study represents the first in a series of analyses of the relationships between perinatal factors and school achievement to be conducted as part of the Educational Follow-Up Study (EFUS), a continuing prospective longitudinal investigation of the learning and behavior outcomes associated with maternal, perinatal and early childhood conditions and events (Balow, Anderson, Reynolds, & Rubin, 1969).

Subjects

The 1245 subjects in the present investigation were all participants both in the EFUS and the Minnesota section of the

national Collaborative Perinatal Research Project (Berendes, 1966). The 1559 participants in the EFUS were born at the University of Minnesota Hospital during the early 1960's and have been followed from the time of birth. Although subjects were not initially selected on a random basis, the distribution of the study population on such dimensions as SES and IQ are representative of the white urban population of the North Central States (Myrianthopoulos & French, 1968; Rubin, 1972). All EFUS subjects who had been administered the MRT at pre-first grade level were included in the present analysis.

Procedure

Maternal variables were recorded during pregnancy and delivery. The majority of infant variables were obtained during the neonatal period with additional neurological and physical examinations and the Bayley Scales of Mental and Motor Development administered during the first year of life. Observations were made and recorded following standardized protocols developed for use by all Collaborative Project Hospitals.

The 76 maternal, perinatal and early childhood measures[2] include the following:

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[2]Maternal, perinatal, neurological and developmental examinations were administered at the University of Minnesota Hospitals and made available through the cooperation of the Collaborative Perinatal Research Project.

(a) Demographic characteristics of the pregnant woman - 4 variables

(b) Maternal reproductive history - 6 variables

(c) Maternal medical history - 9 variables

(d) Variables specific to pregnancy with the study child - 14 variables

(e) Delivery - 7 variables

(f) Measures of the neonate - 29 variables

(g) Neurological and non-neurological examinations during the first year of life - 5 variables

(h) Measures of mental and motor development during the first year of life - 2 variables

During the summer of the calendar year in which subjects reached their sixth birthday, prior to entering first grade, trained educational examiners individually administered the Metropolitan Readiness Tests (MRT) to all available EFUS subjects. The MRT is a measure of skills and abilities such as auditory and visual perception, motor coordination, linguistic skills and knowledge of numbers which contribute to readiness for initial first grade work.

Analysis

Study data were subjected to two sets of analytic procedures:

A. Subjects were divided into high and low readiness groups on the basis of performance on the MRT. The high group consisted of 892 subjects with MRT total raw scores of 45 or higher since interpretations provided in the MRT

Manual of Directions (1965) indicate that students scoring at or above this level are likely to succeed in first grade work. The low group consisted of 353 subjects whose MRT total scores were below 45 since the MRT Manual suggests that those with scores falling below this level are likely to have difficulty mastering first grade work. High and low readiness groups were compared on each of the 76 maternal and infant variables.

The coding of 42 of the 76 maternal and infant variables was ordinal-categorical in nature (e.g. results of neurological evaluations were coded as 0 = Normal, 1 = Suspect, and 2 = Abnormal). The remaining 34 variables were continuous, as in duration of labor which was reported in total number of minutes.

Chi-square tests were used to determine whether the high and low readiness groups differed significantly on the 42 categorical variables while t-tests of the differences between mean scores were used to contrast the two groups on the 34 continuous variables.

B. All 76 maternal and perinatal variables were entered into a multiple regression equation to predict MRT scores for the full sample of 1245 subjects.[3] Multiple correlation

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[3]Regression coefficients were computed using the Correlation and Multiple Linear Regression Program (UMST500) of the University of Minnesota Computer Center, Minneapolis, Minnesota.

coefficients predicting MRT scores were also computed separately for each of the eight groups of maternal and infant variables.

Results

For the total group of 1245 subjects the mean MRT score was 54.9 which falls at the 50th percentile on the standardization norms for this instrument as reported in the MRT Manual of Directions (1965). MRT mean scores of 63.6 for the high and 32.9 for the low readiness groups fell at the 69th and 14th percentiles respectively on the test standardization norms.

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Insert Tables 1, 1a, 1b
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Significant differences (<.05) favoring the high readiness group were found between high and low readiness groups on 9 maternal variables and 11 infant variables.

Mothers of the low readiness group:

1. were older at time study subject was born
2. were lower in socioeconomic level
3. had less formal education
4. had more children now living
5. had more prior live births
6. had more abortions and ectopic pregnancies
7. more frequently had sensory defects
8. more frequently had seizures
9. more frequently had been diagnosed as retarded

The low readiness group of children had:

1. more abnormal deliveries
2. more cord clamped before delivery

3. more frequently abnormal cry at birth
4. fewer ratings of normal skin at birth
5. more cyonatic skin at birth
6. more combinations of abnormal skin conditions at birth
7. more identified abnormalities at birth
8. lower birth weight
9. more neurological abnormalities at 1 year of age
10. lower Bayley Mental Scale scores at 8 months of age
11. lower Bayley Motor Scale scores at 8 months of age

Significant differences (<.05) favoring the low readiness group were found on five maternal variables:

Mothers of low readiness children had:

1. less blood pressure rise to labor
2. less blood pressure rise intra-partum
3. less weight gain to labor
4. fewer toxemia screen failures
5. fewer toxemia problems

The above variables are all toxemia related. Toxemia is known to occur more frequently during first pregnancies and a significantly higher proportion of our high readiness subjects were first born children. A careful analysis of the data revealed that the incidence of these toxemia related problems was indeed associated with the higher frequency of first pregnancies in the high readiness group. This situation is illustrative of the complex interrelationships among the variables under investigation and serves as a reminder that one must be most cautious regarding interpretations of the findings thus far.

Insert Table 2

Each of the eight variable groups were independently entered in multiple regression equations to predict MRT scores for the total sample. Results are reported in Table 2. The total multiple correlation of .57 based on all 76 of the study variables accounted for 33 percent of the total variance in MRT scores. Variable Group (a) which consists of SES and closely related measures provided the highest of the independent group predictions of MRT performance accounting for 21 percent of the total variance. Variable Groups (f) Neonatal and (h) Infant Developmental Examinations were the next highest independent predictors of MRT performance accounting for six and seven percent of the total variance respectively. Group (c) consisting of maternal medical history variables showed the lowest relationship to MRT scores.

Conclusions

Results of this study indicate that subjects grouped according to level of readiness for first grade work at age six differ significantly on a number of maternal and infant characteristics. When compared to subjects with high readiness levels, subjects with low readiness levels were found to have a higher total number of abnormalities at the time of birth, more frequently manifest abnormal skin conditions at birth, had lower scores on measures of mental and motor development at 8 months, and had more neurological abnormalities at one year of age. Mothers of low readiness subjects were, on the average, older, of lower socioeconomic status and had more prior pregnancies than mothers of high readiness subjects.

When 76 maternal and infant variables were entered into a multiple regression equation to predict pre-first grade readiness scores they yielded a total multiple correlation of .57 accounting for 33 percent of the variance in school readiness scores. The group of variables most closely related to socioeconomic status had the highest independent correlation with readiness scores (R = .45). Infant Developmental Exams (R = .26) and Neonatal Variables (R = .25) were the variable groups showing the next highest correlations with readiness scores.

The findings lend support to the hypothesis that readiness for formal school instructional activities is related to events, circumstances and conditions which can be identified from the perinatal period through the end of the first year of life. These variables can help to establish criteria for early identification of infants "at risk" for low school readiness at age six.

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Table 1

MEAN SCORES OR PERCENT OF ABNORMALITIES

ON 76 MATERNAL AND INFANT VARIABLES

FOR THE TOTAL SAMPLE OF 1245 SUBJECTS

VARIABLES	MEAN SCORE CONTINUOUS VARIABLES	PERCENT ABNORMAL ORDINAL-CATEGORICAL VARIABLES	SIGNIFICANCE OF THE DIFFERENCE BETWEEN HIGH AND LOW READINESS GROUPS*
DEMOGRAPHIC CHARACTERISTICS OF THE PREGNANT WOMAN			
Maternal Age	23.89		.00*
SES	54.43		.00*
Highest Grade Completed	12.01		.00*
Marital Status (Unmarried)		6.1	.30
MATERNAL REPRODUCTIVE HISTORY			
Total Live Born	1.87		.00*
Number of Abortions, Ectopic Pregnancies	.25		.00*
Previous Pregnancy - Motor Defect	.02		.74
Previous Pregnancy - Sensory Defect	.02		.36
Previous Pregnancy - Retardation	.03		.08
Total Children Now Living	1.80		.00*
MATERNAL MEDICAL HISTORY			
History of Hypertension		12.4	.15
Congenital Malformation		1.4	.60
Other Physical Defect		3.9	.68
Sensory Defect		1.0	.01*
Diabetes		1.4	.18
Seizures		4.9	.00*
Motor Defect		1.2	.66
Mental Retardation		.4	.04*
Mental Illness		3.5	.65
VARIABLES OF THIS PREGNANCY			
Complications	.14		.51
Infectious Diseases	.15		.17
Total Number of Diseases	3.31		.07

VARIABLES	MEAN SCORE CONTINUOUS VARIABLES	PERCENT ABNORMAL ORDINAL-CATEGORICAL VARIABLES	SIGNIFICANCE OF THE DIFFERENCE BETWEEN HIGH AND LOW READINESS GROUPS*
Blood Pressure up to Labor		1.8	.16
Blood Pressure Rise up to Labor		38.4	.01*
Blood Pressure Rise Intra-Partum		64.9	.00*
Proteinuria - 24th Week of Pregnancy up to Labor		.6	.68
Persistent Edema Above Waist up to Labor		15.3	.25
Persistent Edema Above Waist Intra-Partum		1.0	.22
Weight Gain up to Labor		50.4	.03*
Toxemia Screen		85.9	.03*
Length of Gestation		14.1	.07
Toxemia		17.8	.03*
Toxemia Recode		17.9	.12
VARIABLES OF DELIVERY			
Duration of Labor - 3rd Stage	5.95		.42
Total Duration of Labor	444.24		.74
Duration of Labor - Stage 1 and Stage 2	444.85		.34
Forceps	.10		.75
Special Procedures at Birth		14.3	.99
Type of Delivery		32.4	.00*
Any Cord Pathology		27.5	.18
NEONATAL VARIABLES			
48 Hour Serum Bilirubin	5.54		.42
Cord Clamp Time	.46		.89
First Breath Time	.07		.05*
First Cry Time	.23		.06
1 Minute Apgar Total	7.80		.09
5 Minute Apgar Total	8.82		.07
First Bilirubin	5.53		.27
Highest Bilirubin Total	6.32		.30
Clinical Impressions - CNS Defect or Injury	.07		.81
Congenital Problems Other than CNS	.25		.26
Other Clinical Impressions	.63		.08
Jaundice	2.15		.41
Total Number of Abnormalities	.52		.03*
Neurological Abnormalities	.17		.42
CNS Malformation	.02		.20
Birth Weight	332.77		.00*

VARIABLES	MEAN SCORE CONTINUOUS VARIABLES	PERCENT ABNORMAL ORDINAL-CATEGORICAL VARIABLES	SIGNIFICANCE OF THE DIFFERENCE BETWEEN HIGH AND LOW READINESS GROUPS*
Cord Clamp: Before or After Delivery		8.7	.05*
First Cry: Before or After Delivery		28.1	.22
Moro Reflex		10.3	.06
Cry		4.1	.00*
Normal Skin		31.7	.00*
Cyanosis Skin		11.9	.02*
Stained Skin		1.9	.89
Combination Codes on Skin		10.4	.02*
Dysmaturity		6.7	.81
Direct Coombs		3.8	.55
Report of CNS Last Exam		.6	.68
Head Circumference		27.1	.85
Percent Birthweight Lost		36.1	.17
EXAMINATIONS DURING FIRST YEAR			
Neo-Natal Neurological Diagnosis		3.9	.60
4-Month Neurological Abnormalities		4.5	.08
4-Month Non-Neurological Abnormalities		22.6	.90
1-Year Neurological Abnormalities		6.3	.00*
1-Year Non-Neurological Abnormalities		20.2	.79
INFANT DEVELOPMENTAL EXAMS			
Eight Month Mental	79.05		.00*
Eight Month Motor	33.63		.00*

*Variables with chi square or t values significant at or beyond the .05 level.

Table 1a

DIFFERENCES BETWEEN HIGH AND LOW READINESS

GROUPS ON CONTINUOUS MATERNAL AND INFANT VARIABLES

CONTINUOUS VARIABLES	HIGH READINESS GROUP MEAN SCORE N=892	LOW READINESS GROUP MEAN SCORE N=353	t Ratio[1]	p Value*
DEMOGRAPHIC CHARACTERISTICS OF THE PREGNANT WOMAN				
Maternal Age	23.58	24.67	-3.01	.00*
SES	56.50	42.15	14.30	.00*
Highest Grade Completed	12.51	10.75	10.34	.00*
MATERNAL REPRODUCTIVE HISTORY				
Total Live Born	1.63	2.46	-5.83	.00*
Number of Abortions, Ectopic Pregnancies	.20	.38	-3.81	.00*
Previous Pregnancy - Motor Defect	.02	.03	-.34	.74
Previous Pregnancy - Sensory Defect	.02	.03	-.91	.36
Previous Pregnancy - Retardation	.02	.05	-1.75	.08
Total Children Now Living	1.58	2.37	-5.85	.00*
VARIABLES OF THIS PREGNANCY				
Complications	.14	.16	-.67	.51
Infectious Diseases	.14	.17	-1.36	.17
Total Number of Diseases	3.21	3.56	-1.83	.07
VARIABLES OF DELIVERY				
Duration of Labor - 3rd Stage	6.07	5.66	.80	.42
Total Duration of Labor	446.10	439.54	.33	.74
Duration of Labor - Stage 1 and Stage 2	292.60	331.82	-.96	.34
Forceps	.11	.10	.32	.75
NEONATAL VARIABLES				
48 Hour Serum Bilirubin	5.59	5.43	.82	.42
Cord Clamp Time	.45	.47	-.13	.89
First Breath Time	.06	.11	-1.95	.05*
First Cry Time	.18	.34	-1.89	.06
1 Minute Apgar Total	7.85	7.67	1.69	.09
5 Minute Apgar Total	8.85	8.74	1.81	.07
First Bilirubin	5.59	5.37	1.11	.27
Highest Bilirubin Total	6.40	6.13	1.03	.30
Clinical Impressions - CNS Defect or Injury	.08	.06	.24	.81
Congenital Problems Other than CNS	.22	.33	-1.13	.26
Other Clinical Impressions	.56	.83	-1.77	.08
Jaundice	2.20	2.03	.82	.41
Total Number of Abnormalities	.45	.71	-2.24	.03*
Neurological Abnormalities	.16	.21	-.81	.42
CNS Malformation	.02	.03	-1.28	.20
Birth Weight	3356.87	3253.86	3.09	.00*
INFANT DEVELOPMENTAL EXAMS				
Eight Month Mental	76.60	77.65	4.62	.00*
Eight Month Motor	34.10	32.44	5.39	.00*

1. When high and low readiness groups had equal variances ($p>.05$ for F where F = larger variance/smaller variance), Student's t with $df = (n_1 + n_2 - 2) = (892 + 353 - 2)$ was computed. When variances for high and low readiness groups were unequal, an approximation to Student's t was computed according to Satterthwaite (1946).

* Variables with t values significant at or beyond the .05 level.

Table 1b

DIFFERENCES BETWEEN HIGH AND LOW READINESS

GROUPS ON ORDINAL-CATEGORICAL MATERNAL AND

INFANT VARIABLES

ORDINAL-CATEGORICAL VARIABLES	HIGH READINESS GROUP PERCENT ABNORMAL N=892	LOW READINESS GROUP PERCENT ABNORMAL N=353	Chi Square	p Value
DEMOGRAPHIC CHARACTERISTICS OF THE PREGNANT WOMAN				
Marital Status (Unmarried)	5.6	7.4	.08	.30
MATERNAL MEDICAL HISTORY				
History of Hypertension	11.3	15.3	3.73	.15
Congenital Malformation	1.3	1.7	1.86	.60
Other Physical Defect	4.2	3.2	1.49	.68
Sensory Defect	.4	2.3	6.95	.01*
Diabetes	1.2	2.0	3.46	.18
Seizures	3.7	7.9	14.16	.00*
Motor Defect	1.3	.8	.19	.66
Mental Retardation	.1	1.1	4.29	.04*
Mental Illness	3.3	4.0	.20	.65
VARIABLES OF THIS PREGNANCY				
Blood Pressure up to Labor	1.5	2.8	1.93	.16
Blood Pressure Rise up to Labor	40.6	32.9	6.05	.01[1]
Blood Pressure Rise Intra-Partum	67.7	57.8	10.50	.00[1]
Proteinuria - 24th Week of Pregnancy up to Labor	.7	.3	.17	.68
Persistent Edema Above Waist up to Labor	16.1	13.3	1.35	.25
Persistent Edema Above Waist Intra-Partum	1.2	.3	1.50	.22
Weight Gain up to Labor	52.5	45.3	4.80	.03[1]
Toxemia Screen	87.3	82.4	4.62	.03[1]
Length of Gestation	12.9	17.0	3.20	.07
Toxemia	19.0	14.4	10.41	.03[1]
Toxemia Recode	19.3	14.4	4.28	.12
VARIABLES OF DELIVERY				
Special Procedures at Birth	14.2	14.4	.00	.99
Type of Delivery	5.9	7.6	11.08	.00*
Any Cord Pathology	26.3	30.3	1.80	.18
NEONATAL VARIABLES				
Cord Clamp: Before or After Delivery	7.6	11.3	3.93	.05*
First Cry: Before or After Delivery	29.1	25.5	1.49	.22
Moro Reflex	9.2	13.0	3.63	.06
Cry	2.9	7.1	11.67	.00*
Normal Skin	29.3	38.0	8.44	.00*
Cyanosis Skin	10.5	15.3	5.02	.02*
Stained Skin	1.9	2.0	.02	.89
Combination Codes on Skin	9.1	13.6	5.08	.02*
Dysmaturity	5.6	5.9	.96	.81
Direct Coombs	4.0	3.1	.36	.55
Report of CNS Last Exam	.7	.3	.17	.68
Head Circumference	27.4	26.6	.04	.85
Percent Birthweight Lost	36.7	34.6	3.58	.17
EXAMINATIONS DURING FIRST YEAR				
Neo-Natal Neurological Diagnosis	3.7	4.5	.27	.60
4-Month Neurological Abnormalities	3.8	6.3	2.90	.08
4-Month Non-Neurological Abnormalities	22.4	22.9	.02	.90
1-Year Neurological Abnormalities	4.8	10.4	13.23	.00*
1-Year Non-Neurological Abnormalities	20.4	19.6	.07	.79

* Variables with chi square values significant at or beyond the .05 level.

[1] Toxemia variable, frequently associated with first pregnancies.

Table 2

MULTIPLE CORRELATION COEFFICIENTS FROM REGRESSION ANALYSES USING EACH OF THE EIGHT VARIABLE GROUP TO INDEPENDENTLY PREDICT MRT SCORES FROM THE TOTAL SAMPLE OF 1245 SUBJECTS

VARIABLE GROUP	R	R^2
(a) Demographic Characteristics of the Pregnant Woman	.45	.21
(b) Maternal Reproductive History	.22	.05
(c) Maternal Medical History	.14	.02
(d) Variables of this Pregnancy	.19	.04
(e) Delivery Variables	.17	.03
(f) Neonatal Variables	.25	.06
(g) Examinations During First Year	.17	.03
(h) Infant Developmental Exams	.26	.07
All eight variable groups entered simultaneously	.57	.33